6.8 Central Puget Sound

In this section we assess salmon and bull trout use, food web and ecological conditions, landscape conditions, and threats.

1. Salmon Use

Chinook

This is part of the Central and South Puget Sound Region which includes six independent populations of Chinook. Five of these populations emanate from this sub-basin:

- Lake Washington
- Cedar
- Green
- White
- Puyallup

This sub-basin provides direct support to meeting the Chinook ESU criteria by supporting rearing of juveniles, sub adults, and adults of many populations from almost all geographic regions of origin.

a) Juvenile

- Juvenile Chinook salmon from each of the five natal populations, as well as non-natal populations from throughout Puget Sound, utilize this sub-basin for feeding and growth, refuge, physiological transition and as a migratory corridor (juvenile salmon functions).
- Juvenile Chinook salmon primarily use the Green, Puyallup and Lake Washington areas as a migratory corridor – a link from upper watersheds to Puget Sound.
- Non-natal populations likely derive some function from the smaller freshwater tributaries within this basin.

b) Adult

- Sub-adult and adult salmon from the five natal populations utilize habitats within this sub-basin as a migratory corridor and grazing area.
- Adult Chinook salmon from non-natal populations also utilize this sub-basin

Other Listed Species (not comprehensively reviewed or assessed for this sub-basin)

- Chum salmon: Natal populations of the Hood Canal/Eastern Strait of Juan de Fuca Summer Chum ESU do not exist in this sub-basin. Non-natal use may occur, but it is not known for certain. Non-natal use by early migrant chum salmon from Northern Hood Canal Rivers may extend south into this sub-basin (i.e., Kingston area).
- Bull trout (anadromous): The Puget Sound Management Unit contains two preliminary core areas (Puyallup, Chester Morse) in this sub-basin. The Puyallup watershed is critical for sustaining the distribution of the anadromous bull trout life history trait within Puget Sound because it is the only main watershed in south Puget Sound supporting this life history type. This core area contains an estimated 5 local populations, less than 1000

adult fish (estimated) and an unknown population trend (population numbers generally low) (USFWS 2004).

2. Ecological and Landscape Conditions

Food Web, Ecological Conditions

The Central Puget Sound sub-basin is the most industrialized and populated sub-basin in Puget Sound. The three main natal Chinook estuaries on the eastern shore of this region, Puyallup River at Commencement Bay, Duwamish River at Elliot Bay, and "Salmon Bay" at Shilshole Bay draining Lake Washington, are highly developed. Many of the smaller estuaries and pocket estuaries, as well as shorelines are also developed to varying degrees. As a result, populations of Chinook (and particular life history types) have been impacted more so than populations from other sub-basins.

Portions of this sub-basin exhibit poor water quality, and if not addressed or corrected, may continue to negatively affect the ecology of this sub-basin. Toxic contaminants such as PCBs and PBDEs (and others) are polluting the food web of Puget Sound, particularly the central and south sound basins (three sub-basins: central Puget Sound, Carr-Nisqually, south Puget Sound). Natal Chinook salmon populations from the two basins as well as a primary salmon prey (i.e., Pacific herring) appear to be contaminated with toxics (see following sections for more detail). These "resident" salmon (i.e., natal populations) exhibit greater concentrations of toxics when compared to migratory salmon (i.e., non-natal populations) passing through each sub-basin.

Quartermaster Harbor supports forage fish (e.g., herring) spawning functions, and forage fish are an important prey resource for natal and non-natal salmon populations. A recent oil spill in the Dalcos Passage region spread to Quartermaster Harbor.

Landscape Conditions

The Central Puget Sound sub-basin is the most industrialized and populated sub-basin in Puget Sound, yet it still maintains a fairly high level of ecological function within some ecosystem components. Below are excerpts from the Executive Summary of King County's State of the Nearshore Report for Water Resource Inventory Areas 8 and 9, which make up the bulk of the main basin of Puget Sound.

> Eelgrass forms small patches to large meadows in the low intertidal and shallow subtidal zone of Puget Sound, covering about 57 percent of the shoreline of WRIA 8 and 62 percent of WRIA 9. Kelps occur in small patches to large forests throughout the study area, covering 12 percent of the shoreline in WRIA 8 and 7 percent of WRIA 9, including 6.4 percent within Elliott Bay. Six percent of the shoreline in WRIA 8 and 29.7 percent of the shoreline in WRIA 9 is composed of flats as defined by the ShoreZone database, which does not include lower tidal flats. Over the past century, 97 percent of the shallows and flats in the Duwamish estuary and Elliott Bay have been lost due to dredge and fill operations for urban and industrial development. Although the entire delta was filled in, much of the subsequent shoreline armoring is present in the upper intertidal

zone, and gently sloping mud and sandflats exist in the lower intertidal and subtidal zones. Shoreline armoring, dredging, and filling have probably caused loss of flats in other parts of the study area, as well. Historical filling, diking, armoring, and other human intrusions have eliminated all but a few small tidal marshes in the study area. Dramatic reductions occurred in the Duwamish estuary, where over 1,170 acres of tidal mash was eliminated early in the century. The largest remaining tidal marsh system in WRIAs 8 and 9 is Kellogg Island, within the Duwamish estuary. Most of the shoreline of Puget Sound is composed of gravel, cobble, sand, or silt beaches. Beaches are generally distinguished from flats by their steeper grade, but generally support similar functions. Puget Sound beaches often transition to sandflats at about MLLW. Similar to the use of flats, juvenile salmonids rely on beach environments for foraging and refuge before migrating to deeper water. Adult bull trout and cutthroat trout also forage seasonally in shallow beach habitats at high tides. Beaches and backshore areas can be highly productive; shellfish production is commonly very high on cobble and gravel beaches where deposition includes organic matter. (King County DNR, 2001).

Figures E-8.1 through E-8.5 in Appendix E depict additional information about the landscape condition in central Puget Sound.

Overall area

- Total area (deep-water plus nearshore) is 192,511 acres (300.8 square miles)
- Deep-water portion (marine waters landscape class) comprises 158,655 acres (247.9 square miles), or 82% of the total sub-basin area.

Nearshore area

- Nearshore portion comprises 33,856 acres (52.9 square miles), or 18% of the total sub-basin area. As part of the nearshore, the Puyallup, Duwamish and "Salmon Bay" deltas are natal deltas for the independent Chinook populations listed above, comprising 3.22 square miles (6%) of the total nearshore area within this sub-basin.
- Nearshore area within this sub-basin is 8% of the nearshore area of the entire Puget Sound basin.
- Contains 308 miles of shoreline (beaches landscape class).
- The "key" bays (landscape class) identified in this sub-basin are Shilshole Bay, Elliot Bay, Commencement Bay, Gig Harbor, Quartermaster Harbor, Clam Bay, Blakely Harbor, Eagle Harbor, Murden Cove, Port Madison, Miller Bay, Appletree Cove, and Cultus Bay.
- Sixty-six linear miles (21%) of the shoreline is designated as marine riparian (defined as the estimated area of length overhanging the intertidal zone).
- In this sub-basin, 50% of the shoreline (154 linear miles) has eelgrass (*Zostera marina* and *Z. japonica*); may be patchy or continuous.
- In this sub-basin, 10% of the shoreline (32 linear miles) has floating kelp; may be patchy or continuous. Also in this sub-basin, 23% of the shoreline (71 linear miles) has non-floating kelp; may be patchy or continuous.

Pocket Estuary Analysis

We identified 37 pocket estuaries in this sub-basin: most of these are located on the western shorelines of this sub-basin; only a few are located on the east shore of the basin and most of these are north of Edmonds.

- Freshwater sources were observed in nearly two-thirds of the pocket estuaries,
- Based on the assumptions listed in Appendix B, all three of the Chinook functions (feeding, osmoregulation and refuge) were estimated were estimated to occur in 12 of the 37 pocket estuaries. Most of the remaining pocket estuaries were estimated to have two of the three Chinook functions,
- Fifteen pocket estuaries were estimated to be *properly functioning*. Four pocket estuaries were estimated to be *not properly functioning*. The remaining 18 pocket estuaries were recorded as *at risk*.

Drift Cell Analysis

A drift cell characterization developed for this sub-basin is presented in Appendix E, Figure E-8.5 and subsequent text. Highlights of recommendations for protection and restoration are included in Tables 6-16 and 6-17.

Threats/stressors

For a detailed listing of threats and stressors identified for Central Puget Sound, refer to King County's State of the Nearshore Report, 2001.
http://dnr.metrokc.gov/wlr/watersheds/puget/nearshore/sonr.htm

Loss and/or simplification of delta and delta wetlands

Comparison of historical wetland area and wetland area reported in Bortleson et al. (1980) revealed that for the Duwamish delta, the estimate area of subaerial wetlands decreased from historical to date of survey in 1980 from 1.0 to 0.01 square miles (decreased by 0.99 square miles). The estimated area of intertidal wetlands decreased from historical to date of survey in 1980 from 3.28 to nearly 0 square miles (decreased by as much as 3.28 square miles). Extensive dredge and fill operations have resulting in a nearly 100% loss of intertidal wetlands from historic conditions in the Duwamish delta is nearly 2,100 acres.

Comparison of historical wetland area and wetland area reported in Bortleson et al. (1980) revealed that for the Puyallup delta, the estimate area of subaerial wetlands decreased from historical to date of survey in 1980 from 3.86 to nearly 0 square miles (decreased by as much as 3.86 square miles). The estimated area of intertidal wetlands decreased from historical to date of survey in 1980 from 2.86 to 0.04 square miles (decreased by 2.82 square miles). Extensive dredge and fill operations have resulting in a 98% loss of intertidal wetlands (1,804 acres) from historic conditions in the Puyallup delta.

Alteration of flows through major rivers

In the Green/Duwamish River drainage a re-distribution of flows has occurred. Prior to 1900, several rivers drained nearly 1600 square miles before forming the Duwamish River and ultimately emptying into Elliot Bay (King County, 2002). By 1916, the drainage network was substantially altered, with three rivers re-routed from the Green/Duwamish system and a nearly one-third reduction in the total drainage area (King County, 2002) (Figure 4-6). In addition, a diversion dam and flood control dam blocking upstream fish passage was erected on the upper Green River and a hatchery opened on the same river in 1901-02. The lower Green/Duwamish River was dredged, channelized, shortened and straightened to better facilitate navigation (King County, 2002).

Modification of shorelines by armoring, overwater structures and loss of riparian vegetation/LWD

The projected population growth in King, Snohomish, and Pierce counties between 2000-2025 is 20% (355,356 people), 53% (323,290 people), and 34% (241,337 people) respectively (PSAT 2004). In this sub-basin, shoreline armoring occurs along nearly 179 miles (58%) of the shoreline. Over 136 miles of shoreline are classified as 100% armored. Eighty-seven miles are classified as 0% armored. The total number of overwater structures is 10,448, consisting of ramps (251), piers and docks (838), small slips (9,032) and large slips (327). Overwater structure are observed in greater concentrations in Commencement Bay and Tacoma, Duwamish waterway and Elliot Bay. These structures are also evident along much of the eastern shoreline of the sub-basin, as well as Vashon and Maury Island, eastern half of Bainbridge Island, and part of Colvos Passage. Within 300 feet of shore railroad grades occur along 18.9 miles, following the shoreline in the Tacoma area, and from Ballard north to Mukilteo.

Contamination of nearshore and marine resources

Regions with 15% or greater impervious surface are found along most of the eastern shore of this sub-basin (PSAT 2004).

Sediment samples analyzed from 1997-1999 reveal the central Puget Sound region to have the greatest degree of degraded sediments (PSWQAT 2002a). Chemical concentrations in Puget Sound sediments are typically greater in urban/industrialized regions, such as in Elliot Bay and Commencement Bay (PSWQAT 2002a). 4.6 percent of the area of central Puget Sound is contaminated about state sediment quality standards and 2.6% of the area exceeds the cleanup screening levels.

See Figure E-8.3 for a depiction of the distribution of water quality impairments in central Puget Sound.

Alteration of biological populations and communities

Pacific herring have been found to be "3 to 11 times more contaminated with PCBs in central and south Puget Sound than the Strait of Georgia" (WDFW, unpublished data). These WDFW

results from 2004 are similar to those reported in 1999 and 2000 in PSWQAT (2002a), where body burdens of PCBs were higher in Pacific herring from the central basin (Port Orchard) and southern Puget Sound basin (Squaxin Pass) than Pacific herring from northern Puget Sound and the Strait of Georgia.

There are approximately 30 hatcheries releasing various species of salmonids into the main basin of Puget Sound, the highest concentration of hatcheries of any sub-basin. This may affect community structure at certain times of the year, especially if hatchery releases are not appropriately timed to avoid over-utilization of available prey resources or predation of wild fish. Because of poor water quality, there are no commercial shellfish aquaculture operations in the Main Basin, however, there are several floating net pen aquaculture facilities. Overharvest of fisheries species in the past, continued recreational fishing pressure, loss of critical habitats and poor water quality have potentially greatly altered biological populations and communities within the main basin but comparative studies with other sub-basins in Puget Sound have not been conducted.

Specific hatchery reform recommendations for this region have been formulated by the Hatchery Scientific Review Group available at the following websites.
http://www.lltk.org/pdf/HSRG_Recommendations_February_2002.pdf
http://www.lltk.org/pdf/HSRG_Recommendations_March_2003.pdf

Transformation of land cover and hydrologic function of small marine drainages via urbanization

In many cases, the historic pocket estuaries of the main basin have been completely filled or drained for development. The University of Washington River History Project in cooperation with Washington Department of Natural Resources and the Puget Sound Nearshore Ecosystem Restoration Project, is conducting an analysis of central Puget Sound shorelines using historical maps and data sets to ascertain how many small marine discharges and their associated marsh and mudflat features may have been lost in the Main Basin over the last 150 years. .

Figure E-8.4 lists of pocket estuaries we identified in central Puget Sound and evaluates the stressors on these pocket estuaries based on our review of oblique aerial photos.

Transformation of habitat types and features via colonization by invasive plants

One percent of the shoreline (4 miles) contains *Spartina spp*; may be patchy or continuous. 26% of the shoreline (81 miles) contains *Sargassum muticum*; may be patchy or continuous. Because of the proximity of these shorelines to developed urban and suburban areas, the presence of invasive escaped garden plants is high even in relatively undisturbed parkland. Scotch broom, English ivy and Japanese knotweed are particularly abundant along shoreline parks and forested residential properties.

B. Evaluation

In this section we list goals and evaluate the level of realized function for natal and non-natal Chinook, summer chum, and bull trout. From this we then list each of the proposed protection and restoration actions for this sub-basin, and describe the benefits to natal Chinook, non-natal Chinook, and summer chum and bull trout (if any).

Goals for listed salmon and bull trout whose natal streams are in this sub-basin

a) Provide early marine support for life history types of the independent Chinook populations emanating from this sub-basin,
b) Provide support for sub-adult and adult Chinook salmon populations who utilize habitats within this sub-basin as a migratory corridor and grazing area,
c) Provide marine support for sub-adult and adult anadromous bull trout populations (5) within the two core areas in this sub-basin (Puyallup, Chester Morse).
d) Provide for connectivity of habitats; also, adequate prey resources, marine foraging areas, and migratory corridors for juvenile, sub-adult and adult Chinook, and bull trout.
e) Provide early marine support for independent spawning aggregations occurring in this sub-basin.

Goals for listed salmon and bull trout whose natal streams are outside this sub-basin.

a) Provide support for all neighboring Puget Sound populations (juveniles, sub-adults, and adults) that utilize nearshore and marine regions of this sub-basin as a migratory corridor.
b) Provide support functions in the northern portion of this sub-basin for early migrant Hood Canal/Eastern Strait of Juan de Fuca Summer Chum, if used.

Realized function for listed salmon and bull trout

Fry migrant Chinook –Independent populations of Chinook salmon from the Green, Puyallup and Lake Washington are at very high risk. Only five pocket estuaries are identified along the extensively armored and expansive, highly urbanized eastern shoreline of this sub-basin (Figure E-8.2 in Appendix E). Just two of the pocket estuaries are estimated to be properly functioning. The remaining pocket estuaries are located on the western shoreline of this sub-basin, opposite the three highly developed natal deltas supporting five independent populations of Chinook salmon. Therefore, there is little opportunity or capacity to access or utilize any shallow water, low-velocity habitats along the same shoreline as the natal deltas. Instead, the small fish may need to traverse across the open waters to access shallow, low velocity areas and pocket estuaries on the western shoreline. There are shallow, protected shorelines within reach of Central Sound rivers where small Chinook can be found along Bainbridge Island shorelines in the spring. While these habitats are within five or ten miles of each natal estuary (Figure E-8.2), it is not known if remnant fry migrant life history types readily exploit habitats on western shores.

In addition, available fry migrants must contend with a host of issues, each affecting the ability to access and derive function from suitable habitats (i.e., connectivity between natal deltas and landscape classes and habitat types). For example, water quantity (reduced due to dams, diversions, developed stream mouths; reduction/loss of seeps and groundwater recharge), water quality (elevated temperature and reduced dissolved oxygen), pollution (chemicals and

wastewater discharges [Figure E-8.3], and elevated body burdens of toxic contaminants such as PCBs and PBDEs in salmon within this sub-basin [WDFW, unpublished data]) and physical attributes (extensively armored eastern shoreline [bulkheads, railroads], clearing and grading of marine riparian vegetation). It is not known if restoration activities would benefit this marginally existent life history type.

Delta fry Chinook – The natal estuaries have been substantially altered from historic conditions. Consequently, the opportunity and capacity for delta fry to utilize habitats within the three estuaries is nearly eliminated. Connectivity between habitat types within the estuary/shorelines and landscape classes is essential for small-sized delta fry emigrating distances to and within this sub-basin. Furthermore, the conditions and stressors described above in the fry migrant section also impact any remnant natal delta fry.

Simenstad (2000) discussed the ability of Commencement Bay and the Puyallup delta habitats to support juvenile salmon. His assessment shows that present-day delta habitats are smaller, extremely fragmented with little or no connectivity, and with numerous stressors impacting the region. Puyallup River freshwater contributions still exist, but lateral water movement within the delta, as well delivery of sediments and organic materials, is not occurring. River flow and sediment contributions fail to extend out into the Bay very far, and therefore sediments cannot adequately replenish nearshore, intertidal and/or shallow subtidal habitats. As a result, the utilization of habitats by one or more of the four life history types is limited. There is little opportunity for delta fry, for example, to derive important rearing and physiological transition functions from the Puyallup delta because these fish, and all juvenile salmon, are thrust into the Commencement Bay and forced to osmoregulate in higher salinities (brackish) than if allowed to osmoregulate in the preferred shallow water, low-velocity regions typical of other estuaries (e.g., Nisqually). It should be noted that juvenile salmon (such as delta fry) are capable of exploiting any shallow water, low-velocity regions, and in fact continue to do so wherever available in the Puyallup delta. Finally, restoration opportunities do exist in this highly urbanized delta (e.g., diversion of some Puyallup River flow through Hylebos waterway to encourage build up of delta).

Parr migrant Chinook – Many of the Puget Sound Chinook salmon migrate to the ocean as sub-yearlings (Myers et. al., 1998), and on average this life history type is the most abundant in Puget Sound. Parr migrants in this sub-basin also include a lake rearing type from Lake Washington. The opportunity exists for larger-sized parr migrants from natal Chinook populations, as well as non-natal populations from throughout Puget Sound to utilize shallow water, low-velocity habitats within the nearshore (e.g., estuaries, pocket estuaries and shorelines), of primarily the western shorelines of this sub-basin. Numerous *properly functioning* (and *at risk*) pocket estuaries are located on Bainbridge, Vashon and Maury Islands, characterized by much less armoring than the eastern shoreline. Non-natal parr migrants moving north from the southern sub-basins, and south out of the Whidbey sub-basin can utilize these nearshore habitats. In addition, juveniles from the Hood Canal/Eastern Strait of Juan de Fuca Summer chum ESU may frequent and utilize habitats within the northern section of this sub-basin. This is not known for certain.

As discussed in the above sections, numerous conditions and stressors affect the natal estuaries, other estuaries, and eastern shoreline of the sub-basin. These also impact natal and non-natal parr migrants moving throughout the Central Sound sub-basin. Connectivity between habitat types and landscape classes is essential to this life history type. Any type of catastrophic event (e.g., oil spill) would likely affect many of the ESA-listed salmon populations within Puget Sound. Guarding against such an event is a critical step to safeguarding populations as they emigrate to the Pacific Ocean.

Yearling Chinook – Any reduction in capacity as a result of non-support of the other life history types (i.e., primarily parr migrants) within this sub-basin will negatively affect yearling migrants. Connectivity between habitat types and landscape classes is also important to yearlings from the three natal populations, and other populations moving about broadly within Puget Sound. Yearling migrants will be exposed to the same types of stressors and ramifications as described in the other sections above. Yearling migrants can derive functions (e.g., foraging, refuge, migratory pathway) from available nearshore habitats as described above. Of special concern are the toxic contaminants polluting the food web in the three southern sub-basins and the body burden effects on salmon. In addition, the forage fish population in Quartermaster Harbor is an important prey species for natal and non-natal yearling life history types, as well as to the smaller-sized juvenile salmon (e.g., parr migrants).

Sub-adult and adult Chinook – Larger fish migrating through this sub-basin must contend with several issues, including toxic contaminants in the food chain, sediment contamination in several urban estuaries, and the potential for oil spills. Researchers from WDFW have documented that, in general, Chinook salmon living in or migrating through Puget Sound (specifically in central and south sound) are more contaminated with PCBs than stocks outside of Puget Sound (e.g., Columbia River, WA coast). See Figure 4.7 in Section 4. Residence time in the central and southern Puget Sound basins is suspected as a "primary predictor of PCB concentration in Chinook salmon" and as such, those salmon spending the greatest amount of time in central and south sound exhibit the greatest PCB concentrations (WDFW, unpublished data) (Figure 4-8). Another toxic contaminant of concern in Puget Sound is PBDEs, a common chemical that, like PCBs, are found in greater concentrations in resident Chinook salmon versus migratory Chinook salmon.

Listed summer chum – We hypothesize that Hood Canal/Eastern Strait of Juan de Fuca summer chum salmon may use the northern portion of this sub-basin, but to what degree is not known.

Anadromous bull trout – Of the two core areas, the Puyallup watershed is critical for sustaining the distribution of the anadromous bull trout life history trait within Puget Sound because it is the only main watershed in south Puget Sound supporting this life history type, and is the southernmost population of bull trout (USFWS 2004). Anadromous bull trout use the Puyallup and White River, and are thought to use habitats in Commencement Bay and other nearshore shorelines (USFWS 2004). Extensive development in the Commencement Bay region is likely impacting bull trout. Furthermore, as with yearling Chinook, and sub-adult and adult Chinook, bull trout may be impacted by contamination of sediments and prey items. Also, the loss of LWD in lower reaches of large rivers and estuaries may have reduced habitat complexity.

Table 6-16. Recommended protection actions for central Puget Sound

Protection action	Benefit to Natal Chinook	Benefit to Other (non-natal) Chinook	Benefit to summer chum, bull trout, other fish
Protect smaller freshwater tributaries	Sustained feeding, growth, osmoregulation and refuge functions	Sustained feeding, growth and refuge functions	Sustained feeding, growth, osmoregulation and refuge functions for anadromous bull trout, summer chum and other species
Protect water quality, especially temperature and dissolved oxygen– must ensure appropriate levels of each are available to any and all life history types utilizing this sub-basin.	Sustained growth and reduced mortality	Sustained growth and reduced mortality	Sustained growth and reduced mortality of anadromous bull trout, summer chum and other species
Protect the forage fish spawning areas in Quartermaster Harbor	Sustained feeding function	Sustained feeding function	Sustained feeding function for anadromous bull trout and other species
Protect all remaining functional shoreline features on Vashon-Maury Island from further degradation. The relative importance of low levels of shoreline development in this heavily armored sub-basin cannot be overestimated.	Sustained feeding, growth, refuge, migration functions, especially for Puyallup and Duwamish populations	Sustained feeding, growth, refuge, migration functions	Sustained feeding, growth, refuge, migration functions for anadromous bull trout and other species
Protect functioning drift cells, feeder bluffs for their role in supporting eelgrass bands and depositional features along Colvos Passage, Maury Island, Narrows and the shoreline from Kingston to Foulweather Bluff. (Shoreline Protection Target Areas 2, 4, 5, 10, 11, 13, 15, 18, 21, 22 in Figure E-8.5). Designate these shorelines for the highest level of protection within shoreline master programs and critical areas ordinances and pass strong policies limiting increased armoring of these shorelines and support landowner incentive programs for conservation.	Sustained feeding, growth, refuge, migration functions	Sustained feeding, growth, refuge, migration functions for populations from all neighboring sub-basins	Sustained feeding, growth, refuge, migration functions for anadromous bull trout, summer chum and other species
Protect against catastrophic events	Sustained growth and migration functions	Sustained growth and migration functions	Sustained growth and migration functions

Table 6-17. Recommended improvement actions for central Puget Sound

Improvement action	Benefit to Natal Chinook	Benefit to Other (non-natal) Chinook	Benefit to summer chum, bull trout, other fish
Add enhanced treatment for stormwater discharging directly to Puget Sound to the same standards as for salmon bearing streams.	Improved growth and reduced mortality	Improved growth and reduced mortality	Improved growth and reduced mortality of anadromous bull trout, summer chum and other species
Consider wastewater reclamation and reuse retrofits for all wastewater discharges into the sub-basin, especially new discharges.	Improved growth and reduced mortality	Improved growth and reduced mortality	Improved growth and reduced mortality of anadromous bull trout, summer chum and other species
Complete and implement plans for diverting some Puyallup River flow through the Hylebos to enhance delta structure and processes.	Improved feeding, growth, osmoregulation and refuge functions	Improved feeding, growth and refuge functions, especially for Nisqually population	Improved feeding, growth, osmoregulation and refuge functions for anadromous bull trout and other species
Restore smaller freshwater tributaries.	Improved feeding, growth, osmoregulation and refuge functions	Improved feeding, growth and refuge functions	Improved feeding, growth, osmoregulation and refuge functions for anadromous bull trout, summer chum and other species
Prioritize and implement cleanups of sediment contaminant hot spots and ongoing toxic discharges	Improved growth and reduced mortality via bioaccumulation in the food chain	Improved growth and reduced mortality via bioaccumulation in the food chain	Improved growth and reduced mortality of anadromous bull trout, summer chum and other species
Restore connections between uplands and shorelines by retrofitting Burlington Northern/Santa Fe railroad grade from Golden Gardens to Mukilteo for improved access to blocked pocket estuaries).	Improved feeding, growth, refuge, migration functions	Improved feeding, growth, refuge, migration functions for populations from all neighboring sub-basins	Improved feeding, growth, refuge, migration functions for anadromous bull trout, summer chum and other species
Conduct limited beach nourishment on a periodic basis to mimic the natural sediment transport processes in select sections where corridor functions may be impaired by extensive armoring (Shoreline Restoration Target Areas 12,16, 17, 20,23 in Fig. E-8.5) and seaward of the railroad grade from Golden Gardens to Mukilteo.	Improved feeding, growth, refuge, migration functions	Improved feeding, growth, refuge, migration functions for populations from all neighboring sub-basins	Improved feeding, growth, refuge, migration functions for anadromous bull trout, summer chum and other species
Encourage voluntary re-vegetation of cleared residential shorelines from Alki Point to Brown Point.	Improved feeding, growth, refuge, migration functions	Improved feeding, growth, refuge, migration functions for populations from all neighboring sub-basins	Improved feeding, growth, refuge, migration functions for anadromous bull trout, summer chum and other species
Reform hatchery practices	Improved feeding, growth and survival	Improved feeding and growth	Improved feeding and growth of anadromous bull trout and summer chum